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# OPTIMIZATION OF PROCESS PARAMETERS FOR MACHINING OF ALUMINUM 6061-O ALLOY ON LATHE AND DRILLING MACHINE

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***ABSTRACT***

***The assessment of the process capability is an important aspect for any machine, may it works for commercial or any other purposes. As this is the motto of the project, the machines in the mechanical laboratories were taken into consideration. In these laboratories, mainly the lathe, drilling and milling machines were taken into consideration for the assessment of the process capability. These machines were considered for the process capability of the turning and drilling on these machines with aluminum 6061-O alloy. Almost 90 specimens were taken into consideration and, their process capability is determined, then along with that the applicability of the machines were also found. This has helped in assessing the process capability of the lathe machines with the respective specimens and their applicability is deeply analyzed.***

***KEYWORDS***: ***Process Capability, Lathe & Drilling***

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Original Article

## INTRODUCTION

Process capability assessment is one of the important parameters to be considered for efficient and effective utilization of the machines. The process capability index will make sense the ability and capability of the machine, as to what extent it can discharge its intended functions. Even though the manufacturing and making of machine is unique, in reality, the machine functioning will alter, because of the difference in the follow up of production planning and its control. Hence, it is the customary responsibility for an engineer to assess the degree of accuracy for utilization of the machine. As a part of this, lathe and drilling machines were considered to perform the turning and drilling operation on aluminum 6061-O alloy work pieces. The process of turning and drilling is repeated over a 30 work pieces for each operation and, the analysis is made for the finding of control limits. Thereby, the control charts were made to know the machine capability. The complete work has been described by the following methodology.

## METHODOLOGY

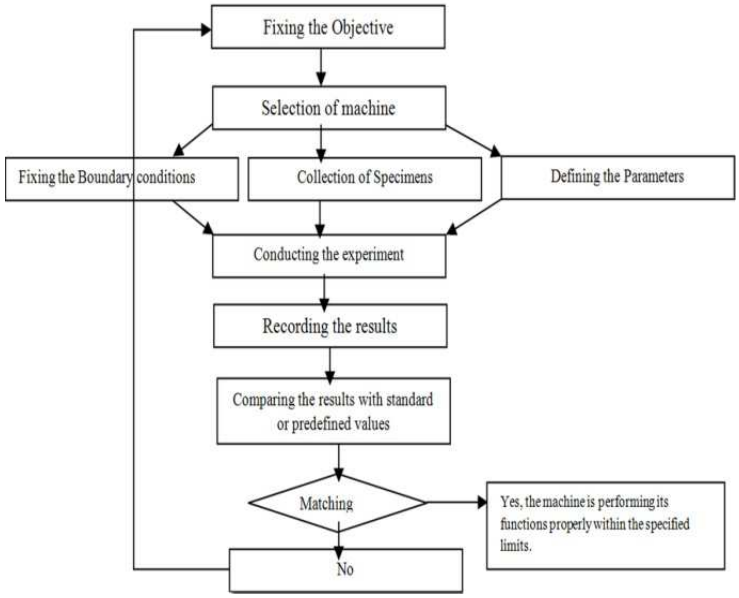


**Figure 1**

The above flow chart describes the method of carrying out the research. At first, some assumptions were made for the work to be done. They are:

- The time taken for machining of all the work pieces is same, as that is a constant.
- The chips that are produced were continuous and it doesn't create any chatter on the surface of the work piece.
- The cutting tool does not get any wear, and it doesn't create any unevenness on the or inside the surface of the work piece.
- Machine is free from vibrations and is fixed properly. That means machine vibrations due to rotating parts do not have any influence on the work piece. For plotting the control charts, the following formula is used.

  For plotting X – CHART

  Upper Control Limit UCL = X + A2R

  Lower Control Limit LCL = X - A2R

  For plotting R – CHART

  Center Line (CL) = R

  Upper Control Limit (UCL) = $RD_4$

  Lower Control Limit (LCL) = $RD_3$

$RD_3$ is the mean of the ranges in the sample process. $A_2$, $D_4$ and $D_3$ are variables in the appropriate statistical (SQC) table.

## ANALYSIS

### Case 1: Lathe Machine

Table shows the data obtained for three attempt of the turning process at various speed and feed rate of the operation. The work piece is of 300mm length and the initial diameter is 45 mm. The number of work pieces is 90.

**Table 1**

| Sub Group Number | Speed (N) RPM | Feed/ rev. (f) | Dia (d1) mm | Dia. (d2) mm | Dia. (d3) mm | Average dia. mm |
|---|---|---|---|---|---|---|
| 1 | 500 | 0.5 | 39.963 | 39.962 | 39.962 | 39.962 |
| 2 | 500 | 0.5 | 39.961 | 39.964 | 39.964 | 39.963 |
| 3 | 500 | 0.5 | 39.965 | 39.955 | 39.955 | 39.958 |
| 4 | 500 | 0.5 | 39.960 | 39.955 | 39.960 | 39.959 |
| 5 | 500 | 0.5 | 39.955 | 39.955 | 39.955 | 39.955 |
| 6 | 500 | 0.5 | 39.960 | 39.960 | 39.960 | 39.960 |
| 7 | 500 | 0.5 | 39.965 | 39.965 | 39.965 | 39.965 |
| 8 | 500 | 0.5 | 39.955 | 39.960 | 39.960 | 39.958 |
| 9 | 500 | 0.5 | 39.960 | 39.965 | 39.965 | 39.963 |
| 10 | 500 | 0.5 | 39.955 | 39.955 | 39.965 | 39.958 |
| 11 | 500 | 0.5 | 39.965 | 39.955 | 39.955 | 39.955 |
| 12 | 500 | 0.5 | 39.960 | 39.960 | 39.960 | 39.960 |
| 13 | 500 | 0.5 | 39.955 | 39.965 | 39.960 | 39.960 |
| 14 | 500 | 0.5 | 39.965 | 39.955 | 39.965 | 39.961 |
| 15 | 500 | 0.5 | 39.955 | 39.960 | 39.960 | 39.958 |
| 16 | 500 | 0.5 | 39.962 | 39.950 | 39.959 | 39.959 |
| 17 | 500 | 0.5 | 39.957 | 39.959 | 39.960 | 39.958 |
| 18 | 500 | 0.5 | 39.959 | 39.962 | 39.961 | 39.960 |
| 19 | 500 | 0.5 | 39.959 | 39.960 | 39.960- | 39.960 |
| 20 | 500 | 0.5 | 39.965 | 39.964 | 39.965 | 39.964 |
| 21 | 500 | 0.5 | 39.963 | 39.962 | 39.962 | 39.962 |
| 22 | 500 | 0.5 | 39.960 | 39.962 | 39.960 | 39.960 |
| 23 | 500 | 0.5 | 39.955 | 39.955 | 39.955 | 39.955 |
| 24 | 500 | 0.5 | 39.955 | 39.955 | 39.955 | 39.955 |
| 25 | 500 | 0.5 | 39.962 | 39.961 | 39.962 | 39.962 |
| 26 | 500 | 0.5 | 39.959 | 39.961 | 39.959 | 39.960 |
| 27 | 500 | 0.5 | 39.960 | 39.961 | 39.958 | 39.960 |
| 28 | 500 | 0.5 | 39.965 | 39.955 | 39.955 | 39.958 |
| 29 | 500 | 0.5 | 39.960 | 39.965 | 39.965 | 39.963 |
| 30 | 500 | 0.5 | 39.962 | 39.961 | 39.963 | 39.962 |

Likewise, the above table, by varying the speed (400rpm & 300 rpm) and feed (0.35 & 0.25 per rev), different diameters was found. As such, a total of 90 readings were receded. For accuracy, each reading is taken at three places around the circumference. And, the average is taken as the standard value.

**Table 2**

| Control Limit Values or Turned Shaft Data | | | | |
|---|---|---|---|---|
| | Center Line | Control Limits | | Standard Deviation |
| | | UCL | LCL | |
| X bar chart | 39.96 | 39.966 | 39.955 | 0.003 |
| R chart | 0.006 | 0.015 | 0 | |

**Case 2: Drilling Machine**

Table shows the data obtained for three attempt of the turning process at various speed and feed rate of the operation. The work piece is of 150mm length and the initial diameter, 207mm. The number of work pieces is 90.

**Table 3**

| Sample | D1 mm | D2 mm | D3 mm | Average mm | Range | Mean mm |
|---|---|---|---|---|---|---|
| 1 | 205.007 | 205.006 | 205.008 | 205.007 | 0.025 | 204.999 |
| 2 | 205.006 | 205.005 | 205.007 | 205.006 | 0.025 | 204.999 |
| 3 | 205.982 | 205.981 | 205.983 | 205.982 | 0.025 | 204.999 |
| 4 | 205.005 | 205.004 | 205.006 | 205.005 | 0.025 | 204.999 |
| 5 | 205.996 | 205.995 | 205.997 | 205.996 | 0.025 | 204.999 |
| 6 | 205.995 | 205.994 | 205.996 | 205.995 | 0.026 | 205.008 |
| 7 | 205.000 | 205.001 | 205.001 | 205.000 | 0.026 | 205.008 |
| 8 | 205.010 | 205.009 | 205.011 | 205.010 | 0.026 | 205.008 |
| 9 | 205.021 | 205.020 | 205.022 | 205.021 | 0.026 | 205.008 |
| 10 | 205.016 | 205.015 | 205.017 | 205.016 | 0.026 | 205.008 |
| 11 | 205.994 | 205.0993 | 205.995 | 205.994 | 0.028 | 204.997 |
| 12 | 205.013 | 205.012 | 205.014 | 205.013 | 0.028 | 204.997 |
| 13 | 205.990 | 205.098 | 205.991 | 205.990 | 0.028 | 204.997 |
| 14 | 205.005 | 205.004 | 205.006 | 205.005 | 0.028 | 204.997 |
| 15 | 205.985 | 205.984 | 205.986 | 205.985 | 0.028 | 204.997 |
| 16 | 205.998 | 205.997 | 205.999 | 205.998 | 0.046 | 205.007 |
| 17 | 205.016 | 205.015 | 205.017 | 205.016 | 0.046 | 205.007 |
| 18 | 205.037 | 205.036 | 205.038 | 205.037 | 0.046 | 205.007 |
| 19 | 205.994 | 205.993 | 205.995 | 205.994 | 0.046 | 205.007 |
| 20 | 205.991 | 205.990 | 205.992 | 205.991 | 0.046 | 205.007 |
| 21 | 205.019 | 205.018 | 205.020 | 205.019 | 0.039 | 205.006 |
| 22 | 205.994 | 205.993 | 205.995 | 205.994 | 0.039 | 205.006 |
| 23 | 205.022 | 205.021 | 205.023 | 205.022 | 0.039 | 205.006 |
| 24 | 205.983 | 205.982 | 205.984 | 205.983 | 0.039 | 205.006 |
| 25 | 205.011 | 205.010 | 205.012 | 205.011 | 0.039 | 205.006 |
| 26 | 205.993 | 205.992 | 205.994 | 205.993 | 0.053 | 205.010 |
| 27 | 205.038 | 205.037 | 205.039 | 205.038 | 0.053 | 205.010 |
| 28 | 205.028 | 205.027 | 205.029 | 205.028 | 0.053 | 205.010 |
| 29 | 205.007 | 205.006 | 205.008 | 205.007 | 0.053 | 205.010 |
| 30 | 205.985 | 205.984 | 205.986 | 205.985 | 0.053 | 205.010 |

Control limits for x bar chart

$UCL = X_2 + A_2R = 205.001 + 0.577*0.033=205.020$

$LCL = X_2 - A_2R = 205.001 - 0.577*0.033= 204.982$

Control limits for R chart

$UCL= D_4R = 2.114*0.033 = 0.070$

$LCL = D_3R = 0.00 * 0.033 = 0$

From the table of standard values for control charts n=5, $A_2$=0.577, $D_2$= 2.326, $D_4$=2.114

## RESULTS

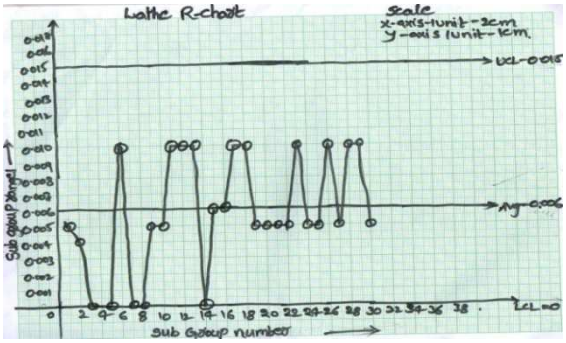


**Figure 2**

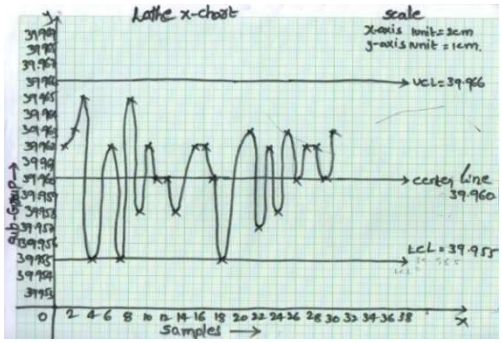


**Figure 3**

By observing the above graphs, it is a clear indication that the machine is producing the elements with the statistical limits, and hence it can be concluded that the machine can be used for the engineering applications.

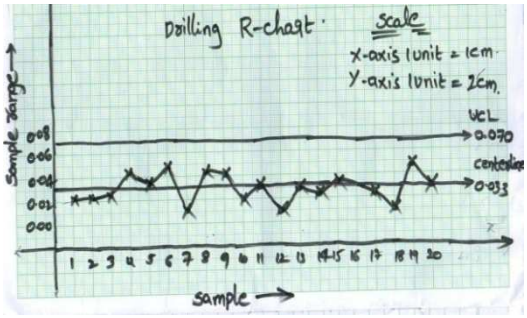


**Figure 4: X Bar Chart for Drilling Machine**

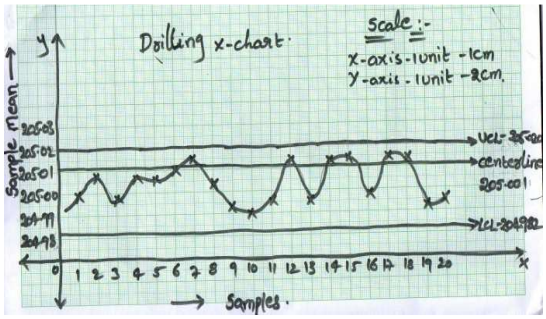


**Figure 5: R Bar Chart for Drilling Machine**

It has been observed that all the plotted sample range and mean values are within the control limits on both R-Chart as well as X bar chart, and there are no indications of Trend, shift, run and clustering.

Hence, it is concluded that the process is under statistical control and operating, under the influence of only chance as causes of variation. i.e. the process is stable over time.

## CONCLUSIONS

The process capability and its assessment for the lathe machine are done, and the machine is capable for performing that particular operation. All the specimen values for these operation lie within the control limits, that is Lower control limit = 39.995mm and the Upper control limit is = 39.966mm. The central limit for this operation is = 39.960mm. In addition to this, the R chart also has been drawn for the same operation. The Upper and Lower control limits for this operation would be 0.015mm and 0mm respectively, and the central limit value is = 0.006mm. This graph also has yielded that the process is within the limits.

Likewise, the Drilling operation also has been considered for the capability assessment. As part of that, the Upper and Lower control limits were 205.020mm and the Upper Control limit value is 24.982mm respectively, and the central limit is 205.001mm. All the specimen values have come within the control limits, hence the process is capable. Then, the R chart also is drawn for the same operation, and it has yielded the Upper and Lower control limits as 0.070mm and 0mm, respectively and, the central limit is 0.033mm. It has also shown that, the values for the operation are within the control limit.

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